ECVAM Protocol for EPISKIN™: an *In Vitro* Assay for Assessing Dermal Corrosivity

Original Draft: March 1997
Confirmed: January 2002

NOTE: This protocol presents the standard operating procedure used in the ECVAM Skin Corrosivity Validation Study (1996/1997). ECVAM confirmed the accuracy of the SOP in October 2000, and this protocol was supplied by Dr. Andrew Worth of ECVAM via email on May 22, 2001.

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EPISKIN™ Test

The corrosivity potential of a chemical may be predicted by measurement of its cytotoxic effect, as reflected in the MTT assay, on the EPISKIN™ reconstituted human epidermis.

Objectives and Application

TYPE OF TESTING	:	screening, replacement
LEVEL OF ASSESSMENT	:	toxic potential, toxic potency, hazard identification
PURPOSE OF TESTING	:	classification and labelling

Proposed replacement for the *in vivo* Draize rabbit skin corrosivity test to be used for hazard identification and classification of corrosive potential to fulfil international regulatory requirements pertaining to the handling, packing and transport of chemicals.

Basis of the Method

Most international regulatory classification schemes define chemically induced dermal corrosion as full thickness destruction (necrosis) of the skin tissue, while some extend the definition of corrosion to include any irreversible alterations caused to the skin. The potential to induce skin corrosion is an important consideration in establishing procedures for the safe handling, packing and transport of chemicals. The determination of skin corrosion potential is therefore included in international regulatory requirements for the testing of chemicals, for example, in OECD testing guideline 404 (Anon., 1992); Annex V of Directive 67/548/EEC (Anon., 1992) and in the U.S. Code of Federal Regulations (Anon., 1991). Corrosivity is usually determined *in vivo* using the Draize rabbit skin test (Draize *et al*., 1944).

The present test is based on the experience that corrosive chemicals show cytotoxic effects following short-term exposure of the stratum corneum of the epidermis. The test is designed to predict and classify the skin corrosivity potential of a chemical by assessment of its effect on a reconstituted human epidermis.

EPISKIN Standard Model™ is a three-dimensional human skin model comprising a reconstructed epidermis with a functional stratum corneum. Its use for skin corrosivity testing involves topical application of test materials to the surface of the skin, and the subsequent assessment of their effects on cell viability. Cytotoxicity is expressed as the reduction of mitochondrial dehydrogenase activity measured by formazan production from MTT. (Fentem *et al*., 1998)

Experimental Description

Endpoint and Endpoint Detection	**:**	cell viability as determined by reduction of mitochondrial dehydrogenase activity measured by formazan production from MTT
Test System	**:**	EPISKIN™ reconstructed human epidermis system *

Test materials are applied to the stratum corneum of the epidermal model (one epidermis unit per test material) for three different exposure periods: 3 minutes, 1 hour, and 4 hours. Exposure to the test chemical was terminated by rinsing with PBS (phosphate buffered saline). EPISKIN cultures exposed to the control compounds for 240 min serve as the controls for all three exposure periods. For each test material, three independent tests with three different batches of EPISKIN are to be undertaken.

The viability of the epidermis is assessed by measuring the mitochondrial activity. The tissues are incubated for 3 hours with MTT solution (0.3 mg/l; 2.2 ml per well). MTT, a yellow-coloured tetrazolium salt, is reduced by succinate dehydrogenase into a blue formazan precipitate in the mitochondria of living cells. The precipitated formazan is extracted overnight by using acidified isopropanol (0.85 ml), and is then quantified spectrophotometrically at a wavelength between 545nm and 595nm.

All experimental procedures have to be conducted at room temperature (18-28°C); if the temperature is below 20°C, the 3-hour MTT incubation should be carried out in a warmer environment of 20-28°C. NaCl (50 µl) and glacial acetic acid (50 µl) are used as negative and positive controls, respectively.

Some highly reactive chemicals can produce fumes, which may affect adjacent units in the same plate. It is recommended that if there is any suspicion that a material could cause fumes, it should be tested alone in a single plate. It is particularly important that the negative control units are not exposed to fumes from other units, hence it is recommended to routinely incubate positive and negative controls in a separate plate.

NOTE: The commercial availability of EPISKIN (SADUC-Biomatériaux Imedex, Chaponost, France) was restricted following the completion of the validation study to enable new production facilities to be completed. It is likely to be available again during 2000. In a subsequent small catch up study, the EPIDERM nodel has been tested and accepted for the assessment of the corrosive potential of chemical substances (INVITTOX No. 119).

Test Compounds

A total of 60 test compounds, consisting of 11 organic acids, 10 organic bases, 9 neutral organics, 5 phenols, 7 inorganic acids, 4 inorganic bases, 3 inorganic salts, 8 electrophiles, 3 soaps/surfactants have been tested in the ECVAM validation study.

Details of the test compounds and test results are available in **dbVas** of ECVAM SIS.

Prediction Model

The test results are interpreted on the basis of the exposure time needed to cause cell viability to decrease below 35%. The determination of the UN packing groups and EU classifications is summarized in the table reported in the section 4.1. **"Interpretation of test results"** of the present standard operating procedure.

Status

This method has been evaluated in the **ECVAM Skin Corrosivity Validation Study** conducted under the auspices of ECVAM during 1996 and 1997 (Fentem *et al*., 1998). The ECVAM Scientific Advisory Committee (ESAC) agreed that the results obtained with the EPISKIN™ test in the ECVAM international validation study on *in vitro* tests for skin corrosivity were reproducible, both within and between the three laboratories that performed the test. The test proved applicable to testing of all the above reported chemical classes of different physical forms. The concordances between the skin corrosivity classifications derived from the *in vitro* data and from the *in vivo* data were very good.

The test was able to distinguish between corrosive and non-corrosive chemicals for all of the chemical types studied; it was also able to distinguish between known R35 (UN packing group I) and R34 (UN packing groups II & III) chemicals. Based on the outcome of the study, the ESAC unanimously endorsed the statement that the EPISKIN test was scientifically validated for use as a replacement for the animal test and that this test was ready to be considered for regulatory acceptance (10th meeting at ECVAM of the ECVAM Scientific Advisory Committee, European Commission, March 1998). (Anon., 1998b).

- The 27th meeting of the Committee for Adaptation to Technical Progress of "Directive 67/548/EEC on the Classification, Packaging and Labelling of Dangerous Substances" agreed that the human skin model assays, which meet certain criteria, would form part of "Annex V method B.40. Skin Corrosion", February 2000 (Commission Directive 2000/33/EC). Furthermore, these models are now under consideration for inclusion in the OECD Guidelines.
  Further details on the ECVAM Validation Study are available in **dbVas** of the ECVAM SIS.

Last update: May 2000

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Procedure Details, March 1997*

EPISKIN™ TEST

NOTE: This protocol presents the standard operating procedure used in ECVAM Skin Corrosivity Validation Study (1996/1997).

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* The accuracy of the SOP has been confirmed in October 2000.

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1. Introduction

Product Description
The EPISKIN-SM™ (Standard Model) kit contains 12 reconstructed epidermis units. Each reconstructed epidermis unit consists of a human collagen (Types III and I) matrix, representing the dermis, covered with a film of Type IV human collagen, upon which stratified differentiated epidermis derived from human keratinocytes has been laid. Test materials can be applied directly to the stratum corneum.

Precautions
The epidermal cells are taken from healthy volunteer donors negative to anti-HIV 1 and 2, and to hepatitis C, antibodies, and to hepatitis B antigens. Nevertheless, normal handling procedures for biological materials should be followed:

(a) it is recommended that gloves are worn during handling; and
(b) after use, the epidermis, the material in contact with it, and the culture medium, should be decontaminated (for example, by using a 10% solution of bleach or a 1% solution of pyosynthene), prior to disposal.

Quality Control
EPISKIN-SM kits are manufactured according to defined quality assurance procedures (certified ISO 9001). All biological components of the epidermis and the kit culture medium have been tested for the presence of viruses, bacteria and mycoplasma. The quality of the final product is assessed by undertaking an MTT cell viability test and a cytotoxicity test with sodium dodecylsulphate (SDS). For reasons connected with the nature of the product, it is shipped before all of the necessary checks have been completed. A release form certifying the conformity (or otherwise) of the batch is sent to the user, by fax, on the day of delivery of the kit.

2. Materials

2.1. KIT CONTENTS

DESCRIPTION	USE
1 EPISKIN-SM plate containing 12 reconstructed epidermis units (area: 0.38cm^2)	each reconstructed epidermis is attached to the base of a tissue culture vessel with an O-ring set and maintained on nutritive agar for transport
1 12-well assay plate	for assays
1 flask of sterile assay medium	basic medium for use in assays
1 EPISKIN-SM biopsy punch	for easy sampling of epidermis

1 lot of "MTT reagents":

1 flask MTT reagent	to reconstitute
1 flask PBS 10x wash solution	to dilute
1 flask 4N NaOH	to adjust pH of wash solution
1 flask extraction solution of isopropanol acid (ready to use)	

1 flask negative control (NaCl, 9g/l) 1 flask positive control (glacial acetic acid)	specific controls for the corrosivity test

2.2. MATERIALS NOT PROVIDED WITH THE KIT

- 500ml wash bottle
- 5ml glass tubes with corks
- 200µl micropipette
- Multidispenser micropipette (2.2ml)
- 50µl or 100µl positive displacement micropipette (for applying thick or viscous samples)
- Vacuum source and Pasteur pipettes
- Small forceps
- Timers
- Microplate reader with filter of 545-595nm and 96-well microplates;
  or spectrophotometer and 1ml microcells
- Vortex mixer
- Non-sterile ventilated cabinet

3. Experimental Procedures and Timing

Details of the kit and assay procedures should be registered on the reporting form (Annex 1).

3.1. RECEIPT OF TEST KIT

Check the date of dispatch written on the package. Before opening the EPISKIN-SM kit:
(a) inspect the colour of the agar medium used for transport and check that its pH is acceptable: orange colour = good; yellow or violet colour = not acceptable;
and
(b) inspect the colour of the temperature indicator to verify that the kit has not been exposed to a temperature above 40°C: the indicator changes from white to grey at 40°C.
In the event of any anomaly, immediately contact the Sales Administration Department at SADUC (Tel: +33 78 56 72 72; Fax: +33 78 56 00 48).

Place the assay medium supplied with the kits at 2-8°C. Leave the EPISKIN-SM kits in their packaging at room temperature until the assays are to be undertaken.

3.2. APPLICATION AND RINSING

Safety precautions: MTT and corrosive materials are dangerous. Work in a non-sterile, ventilated, cabinet, wear protective gloves, and a mask and safety glasses, as necessary. Pre-warm the assay medium to 37°C. An approximate timing for conducting the test procedure is given below as a guide.

9.30: proceed with the application of test material for the 4-hour samples

(a) Fill the appropriate number of wells of an assay plate with pre-warmed culture medium (2.2ml per well). Mark the plate lids with the application time (4 hours) and the code numbers of the chemicals to be tested (1 well per chemical), or negative control (3 wells) or positive control (3 wells).
(b) Open the EPISKIN-SM kits and place an epidermis unit into each prepared well. Mark each epidermis unit with the appropriate code number.

9.45: application of the products during **4 hours:**

(c) Add 50µl of test material to each well by using the positive displacement pipette.
(d) In the case of solids, the material should be crushed to a powder, if necessary, and 20mg applied evenly to the epidermal surface (with difficult materials, use sufficient to cover the epidermal surface); add 100µl NaCl (9g/l saline) to ensure good contact with the epidermis.
(e) Add 50µl NaCl (9g/l saline) to each of the three negative control wells.
(f) Add 50µl glacial acetic acid to each of the three positive control wells.
(g) Replace the lid on the plate and incubate for 4 hours (± 5 minutes) in a ventilated cabinet at room temperature (18-28°C).

Note: The negative and positive controls incubated for 4 hours will act as controls for all of the incubation times.

10.00: proceed with the application of test material for the 1-hour samples

(a) Fill the appropriate number of wells of an assay plate with pre-warmed culture medium (2.2ml per well). Mark the plate lids with the application time (1 hour) and the code numbers of the chemicals to be tested (1 well per chemical).
(b) Open the EPISKIN-SM kits and place an epidermis unit into each prepared well. Mark each epidermis unit with the appropriate code number.

10.15: application of the products during **1 hour**

(c) Add 50µl of test material to each well by using the positive displacement pipette.
(d) In the case of solids, apply 20mg and add 100µl of NaCl (9g/l), as described previously for the 4-hour samples.
(e) Replace the lid on the plate and incubate for 1 hour (± 5 minutes) in a ventilated cabinet at room temperature (18-28°C).

10.30: proceed with the application of test material for the 3-minute samples

(a) Prepare the MTT solution (0.3mg/ml; enough for 2.2ml per well for the entire assay) and the PBS 1x wash solution, as indicated in the "MTT reagents" leaflet accompanying the test kit.
(b) Fill the appropriate number of wells of an assay plate with pre-warmed culture medium (2.2ml per well). Mark the plate lids with the application time (3 minutes) and the code numbers of the chemicals to be tested (1 well per chemical).
(c) Open the EPISKIN-SM kits and place an epidermis unit into each prepared well. Mark each epidermis unit with the appropriate code number.

10.45: application of the products during **3 minutes**

(d) Add 50µl of test material to each well by using the positive displacement pipette. Proceed well by well at 20-second intervals, with the aid of multiple timers (test a maximum of 5 or 6 materials at a time). Ensure that the exposure period is exactly 3 minutes for each well
(e) In the case of solids, apply 20mg and add 100µl of NaCl (9g/l), as described previously for the 4-hour samples.
(f) Remove the EPISKIN-SM unit and rinse thoroughly with PBS 1x solution, to remove all of the test material from the epidermal surface.
(g) Replace the EPISKIN-SM unit in the culture medium.
(h) When all of the units have been rinsed:
- remove the culture medium
- place the units on absorbent paper, or remove the rest of the PBS from the epidermal surface with a Pasteur pipette linked to a vacuum source (be careful not to touch the epidermis)
- add 2.2ml of the MTT solution (0.3mg/ml) to each well
- replace the lid on the plate. If the ambient temperature is 20-28°C, leave to incubate

for 3 hours (± 5 minutes) in a ventilated cabinet at room temperature, **protected from light**. If the ambient temperature is below 20°C, then leave to incubate for 3 hours (± 5 minutes) at temperature of 20-28°C, **protected from light**. An incubator (with or without CO_2), or a warm location within the laboratory, may be used. It is important that all the samples from each exposure time are treated identically.

11.15: rinse the 1-hour samples and replace the culture medium with 2.2ml of MTT solution (0.3mg/ml), as described above.

11.45: place 0.85ml of acidified isopropanol into labelled glass tubes (one tube corresponding to one well of the tissue culture plate). Label each tube with the name of the test material and the incubation time.

13.45: rinse the 4-hour samples and replace the culture medium with 2.2ml of MTT solution (0.3mg/ml), as described above.

3.3. FORMAZAN EXTRACTION

At the end of each incubation with MTT (*14.15*, *14.45* and *17.00*), the formazan extraction should be undertaken:

(a) place the units on absorbent paper
(b) remove the MTT solution from each well
(c) take a biopsy of the epidermis by using the biopsy punch, by placing the epidermis unit on the plate lid
(d) separate the epidermis from the collagen matrix with the aid of forceps, and place both parts (epidermis and collagen matrix) into the acidified isopropanol
(e) cork each tube and mix thoroughly by using a vortex mixer
(f) ensure that the acidified isopropanol is in good contact with all of the material
(g) store at room temperature overnight, protected from light.

3.4. ABSORBANCE/OPTICAL DENSITY MEASUREMENTS

Following the formazan extraction (left overnight):

(a) mix each tube by using a vortex mixer
(b) let the solution settle for 1-2 minutes, so that any cell fragments do not interfere with the absorbance readings
(c) place a 200µl sample from each tube into the wells of a 96-well plate (labelled appropriately)
(d) read the optical densities (OD) of the samples at a wavelength between 545nm and 595nm using acidified isopropanol solution as the blank.
(e) record the results on the template given in Annex 2.

Note: if a spectrophotometer is used rather than a plate reader, place a 500µl sample from each tube and 500µl isopropanol (not acidified) in a 1ml microcell and read the OD at 545-595nm using the acidified isopropanol solution as the blank.

4. Calculations of viability percentages and acceptability criteria

Record all calculations on the Data Report Form (Annex 3).

Viability (%) = 100 x (OD test material/mean OD negative control at 4 hours)

(a) calculate the mean OD of the 3 negative control values: this corresponds to 100% viability. Based on historical data the minimum acceptable mean OD for negative controls is 0.115 (mean ± 2SD). The maximum acceptable mean OD for the negative control is 0.4 (to allow for incubations at 28°C).

(b) calculate the mean OD of the 3 positive control values: the % viability of the positive control is calculated relative to the mean negative control. Based on historical data (mean ±2SD), the acceptable mean percentage viability range for positive controls is 0-20%.

(c) calculate the % viability following exposure to the test material at each incubation time as the OD expressed as a percentage of the mean negative control value.

(d) assay acceptability criteria*:* for an assay to be acceptable, the mean positive and negative control values should fall within the ranges given above.
In those cases where the mean values fall outside the range, the assay should be repeated, except in cases where the same chemical has been tested on at least two other occasions (with acceptable control values) and the results of all of the tests give the same corrosivity classification.

4.1 INTERPRETATION OF TEST RESULTS

The test results are interpreted on the basis of the exposure time needed to cause cell viability to decrease below 35%. The determination of the packing group is summarized in the following table:

Classification	**Packing group**	**Criteria for *In Vitro* interpretation**
UN	Corrosive class I	If viability < 35% after 3 min exposure
	Corrosive class II	If viability ≥ 35% after 3 min exposure and < 35% after 1 hour exposure
	Corrosive class III	If viability ≥ 35% after 1 hour exposure and < 35% after 4 hours exposure
	Non corrosive	If viability ≥ 35% after 4 hours exposure
EU	Corrosive class R35	If viability < 35% after 3 min exposure
	Corrosive class R34	If viability ≥ 35% after 3 min exposure and < 35% after 4 hours exposure
	Non-corrosive	If viability ≥ 35% after 4 hours exposure

In cases where the viability values from individual skin units are highly variable, causing different corrosivity classifications, the chemical should normally be re-tested. If one or more sets of data are considered to be incorrect (or inconsistent with data from other runs), the results should be replaced by those generated in a repeat run.

In cases where the viability values fall below 35%, but longer exposure times give values of >35% (or values higher than the earlier time point), the results should be considered to be doubtful. The run should normally be repeated.

Annex 1

ECVAM SKIN CORROSIVITY VALIDATION STUDY

EPISKIN ™

Assay report form

Experimental center: .....

Kit Reception

Lot number

Date of Receipt

Observations.

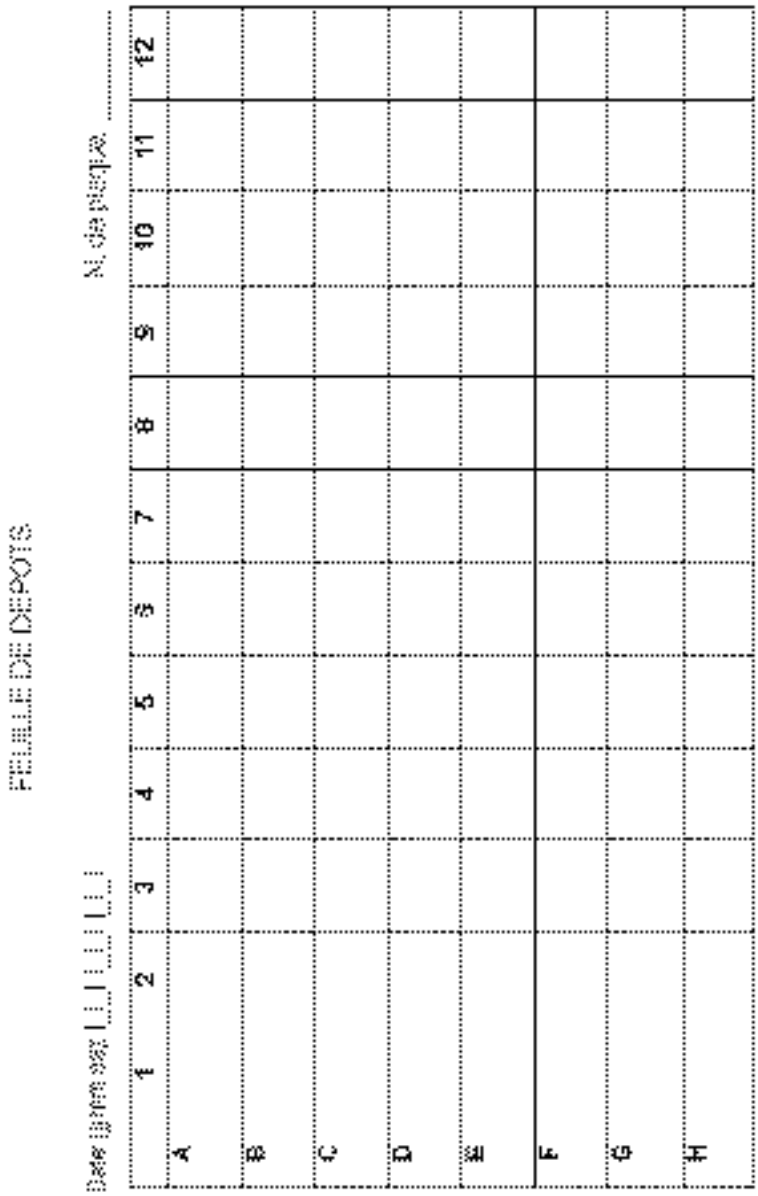
Assay

Date of Assay.

Code of tested product

Observations

Annex 2



Annex 3

ECVAM SKIN CORROSIVITY VALIDATION STUDY EPISKIN™

Data report form

EXPERIMENTAL CHEMICAL

Lot #

Date of assay: / /

Wavelength (nm) used for lecture:

Negative control	
OD 1 OD2 OD3	
Mean	#DIV/0!
% Viability	#DIV/0!

Positive control	
OD 1 OD2 OD3	
Mean	#DIV/0!
% Viability	#DIV/0!

Product Code	Physical Appearance	3 min exposure		1 hour exposure		4 hours exposure	
		OD	% viability	OD	% viability	OD	% viability
			#DIV/0!		#DIV/0!		#DIV/0!
			#DIV/0!		#DIV/0!		#DIV/0!
			#DIV/0!		#DIV/0!		#DIV/0!
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Annex 4

ECVAM SKIN CORROSIVITY VALIDATION STUDY EPISKIN™

Data compilation form

EXPERIMENTAL CENTER:

Product Code	Physical Appearance	Lot N. Episkin	% viability 3 min	% viability 1hr	% viability 4 hrs

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